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From: Amy Sacry, Geum Environmental Consulting, Inc.

CC: Tom Parker, Geum Environmental Consulting, Inc.
Bill Bucher and Karin Mainzhausen, CDM Smith
Karin Boyd, Applied Geomorphology, Inc.

Subject: Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site Pilot Streambank Treatment Project

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This memorandum describes a streambank pilot project completed on March 20 and 21, 2012 in Reach A, Phase 1 of the Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River Superfund Site (CFROU) located near Warm Springs, Montana. The purpose of the streambank pilot project was to evaluate construction feasibility of the Type 2 bank treatment (single vegetated soil lift) included in the CFROU Phase 1 Preliminary Design Plan (PDP) and a modification of the Type 2 bank treatment. The Type 2 bank treatment included in the PDP is a single layer vegetated soil lift constructed on preserved woody bank vegetation. The purpose of this treatment is to provide greater resistance to shear stress in settings where the existing bank has some strength from existing woody vegetation but needs reinforcement because of the reduction in bank height after contaminated material is removed. The modification to the Type 2 bank treatment preserves all existing woody vegetation up to the design top of bank elevation, and no vegetated soil lift is constructed. Figure 1 shows the locations of the two bank treatments constructed as part of the pilot project.

Each treatment is described in the following sections, including:

- Construction sequence
- As-built documentation
- Observations made during installation
- Recommendations for modifying treatments

This document also provides recommendations for monitoring effectiveness of the treatment sites and preliminary criteria on where to apply the Type 2 modified bank treatment.

Figure 1. Location of streambank pilot project treatments.

PDP Type 2 Bank Treatment (Single Vegetated Soil Lift)

The PDP Type 2 bank treatment was constructed between stations 120+00 and 120+50 (Figure 1). The design top of bank elevation at this site is 4,779.5 feet. All existing woody vegetation located one foot below the design top of bank elevation and higher was removed and stockpiled. Vegetation located below this elevation was preserved to maintain bank stability. The downstream half of the preserved vegetation was pruned to a height of approximately three feet. Behind the preserved vegetation, a flat bench was constructed one foot below the design top of bank elevation. The flat bench provides a level surface where the 12-inch coir log used in the vegetated soil lift is placed to create a uniform bank face. The 12-inch flat bench was constructed approximately two feet behind the preserved line of vegetation to create a uniform bank (Figure 2). Behind the flat bench, a trench was excavated to a depth of 3.5 feet below the design top of bank elevation. The slope from the bench to the trench was initially constructed per the PDP at an approximate slope of 1:1. This was modified during construction to a slope of 2:1 to facilitate installation of the vegetated soil lift (Figure 2).

The vegetated soil lift was constructed on the bench and slope according to the PDP using double layer coir fabric and 12-inch normal density coir logs (Figure 3). The vegetated soil lift was filled with a 50:50 mixture of imported six-inch minus alluvium and vegetative backfill. The vegetated soil lift was secured using 18-inch wooden wedge stakes at a spacing of approximately 1.5 per linear foot. Willow cuttings were placed on top of the vegetated soil lift at a density of approximately five per linear foot. Willow cuttings were collected on site and were six to eight feet in length and consisted of *Salix exigua* (sandbar willow). Approximately one to two feet of each cutting extended beyond the front of the vegetated soil lift. The area immediately behind the vegetated soil lift was backfilled with imported floodplain alluvium (see Attachment 1 for material gradation) to approximately 0.4 feet above the design top of bank elevation to allow for settling of material and accommodate possible erosion of material during spring high flows.

As part of the streambank pilot project, this treatment also included excavating contaminated material beyond the bank treatment limits in order to implement floodplain treatments included in the PDP. Existing material was excavated an additional five feet beyond the extent of the bank treatment excavation limits (see PDP Drawing D-2, Detail B). Material was excavated to a depth of 3.5 feet below the design floodplain elevation. This area was backfilled to one foot below design floodplain elevation with imported floodplain alluvium.

After excavation and fill of the floodplain treatment area to within one foot of the design floodplain elevation, a 3.5 foot deep trench was made using the excavator bucket at the interface of the bank treatment and the floodplain treatment, ten feet back from the bank line. Six to eight foot tall sandbar willow cuttings were inserted into this trench at a density of five per linear foot (Figure 4). Because the bank treatment and floodplain treatment were constructed simultaneously, the orientation of the willows is toward the channel rather than away from the channel as shown in the PDP Drawing D-2. Willow cuttings in the upstream half of the treatment were trimmed to approximately two feet above the ground.

Ten, eight-gallon container sandbar willows were planted in the floodplain treatment area. Five of the ten plants (plants 1, 3, 5, 7, and 9 counted from downstream to upstream) were treated with mycorrhizae supplements (Myco Apply®Soluble MAXX) and three packs of fertilizer (Leap Start, Forest Restoration Pro Booster Packs, 22-10-7 plus minors). After planting, the floodplain treatment area was brought up to design floodplain elevation with vegetative backfill material imported from the Beck property borrow site. All container willows were watered in to settle backfill material and ensure no air pockets were present in planting holes. Four of the ten plants (plants 1, 2, 4, and 5 counted from downstream to upstream) were fitted with browse protection consisting of rigid plastic mesh material to prevent cutting by beaver. Browse protectors were four feet tall and ranged from eight to 24 inches in diameter. Both the streambank treatment and floodplain treatment area surfaces were seeded with a mix containing shrub, forb, and grass species (Attachment 2). Seed was lightly raked to improve soil contact.

All material excavated during construction was hauled off site to the Opportunity Ponds Waste Management Area.

Figure 2. Type 2 streambank treatment showing the vegetated soil lift bench, trench and slope between the bench and trench.

Figure 3. Materials used to construct the Type 2 bank treatment including double layer coir fabric, 12-inch normal density coir logs and vegetative backfill mixed with floodplain alluvium.

Figure 4. Placement of willow cuttings at interface between the bank treatment and the floodplain treatment and planting of eight-gallon container willows prior to placement of vegetative backfill.

Figures 5 and 6 show the Type 2 bank treatment site before and after construction. Table 1 provides a list of materials used in the Type 2 bank treatment. The following key observations were made during construction of this treatment:

- Preserved woody vegetation is well rooted into the banks and rooted below the maximum excavation depth.
- The vegetated soil lift bench substrate consisted of sandy loam soil with some clay held together by woody vegetation. The area between the preserved vegetation at the bank line and the face

of the vegetated soil lift should be monitored for erosion, deposition, and natural colonization. The site was observed one week after installation and some cracks were present in this area. It did not appear that the cracks were caused by slumping of the preserved vegetation.

- A few preserved shrubs extended above the constructed bench elevation. Shrubs were preserved if the root ball was located less than one foot above design top of bank elevation (shown below).

Preserved vegetation located approximately 1 foot above final top of bank elevation

- One, three-foot wide gap in the bank vegetation was left after construction of the vegetated soil lift bench (shown below). This gap resulted in an area approximately 0.4 feet lower than the bench elevation. Because the soil lift bench was set back approximately two feet from the edge of the bank, there was no need to fill this gap with woody debris as shown for gaps in vegetation on Drawing D-2, Detail C in the PDP. Other sites where gaps leave deeper holes will require placement of alluvium and woody debris prior to construction of the vegetated soil lift.

Gap in bank vegetation after excavation of vegetated soil lift bench

- Placing willow cuttings at the interface of the bank treatment and floodplain treatment may not be necessary, particularly in areas where planting units overlap with bank treatments.
- The water surface elevation in the channel at the time of bank construction was 4,778.3 feet.
- Backfill of the excavation area was completed one day after excavation and construction of the vegetated soil lift. During this period, the excavation area filled with water to within 0.5 feet of

the water surface in the channel. For this reason, it was not possible to compact the placed alluvium in foot lifts. This may not be a significant issue during construction of the grading plan when the dewatering plan is in place and the excavation is not confined to a small area.

- Alluvium used in the pilot project consisted of material with a high percentage of particles less than 0.5 inches (Attachment 1). This material is smaller than the gradation provided in the PDP and may not be ideal for backfill of bank treatments. Erosion of this material should be monitored for erosion during spring high flows.
- There was beaver browse on cuttings in the vegetated soil lift one week after construction.
- No microtopography was constructed in the floodplain treatment portion of the treatment area. Microtopography is included in the PDP for this area.
- Water quality was not impacted during construction (see Attachment 3).

Based on these observations, the following recommendations for final design of the Type 2 bank treatment include:

- The trench slope should be 2:1 to facilitate backfill and staking of the soil lift, and placement of willow cuttings on the soil lift. Changing the slope will still provide willow cuttings to access perennial moisture.
- A one-foot wide flat bench should be shown under the vegetated soil lift to support placement of the 12-inch normal density coir logs.
- The design willow cutting placement density of five per linear foot in the vegetated soil lifts seems appropriate.
- Placing willow cuttings at the interface of the bank treatment and floodplain treatment may not be necessary at all sites. For final design, cuttings should not be placed at this interface if the area will be planted with containerized plants.
- Not excavating below the design bank elevation directly behind preserved bank vegetation and leaving one to two feet of intact existing bank before excavating the vegetated soil lift bench. This will reduce the risk of erosion behind the preserved vegetation and possibly maintain stability for preserved vegetation.

Figure 5. Type 2 bank treatment site prior to installation of the treatment (photo left) and after installation of the treatment (photo right).

Figure 6. Type 2 bank treatment site prior to installation of the treatment (photo left) and after installation of the treatment (photo right).

Table 1. Summary of materials used for Type 2 bank treatment.

Material Type	**Quantity**
Excavated material	150 cubic yards
Imported alluvium placed	90 cubic yards
Vegetative backfill	22 cubic yards
6-8 foot willow cuttings	500
8-gallon sandbar willows	10
Double-layer coir mat	55 feet (0.6 rolls)
12-inch standard density coir logs	4.5

Type 2 Modified Bank Treatment (Preserve Vegetation)

The Modified Type 2 bank treatment was constructed between stations 122+40 and 122+90 (Figure 1). This treatment is similar to the Type 2 bank treatment except instead of constructing a vegetated soil lift, existing bank vegetation is preserved up to the design top of bank elevation. The design top of bank elevation at this site is 4,779.2 feet. Woody vegetation along the channel above the design top of bank elevation was removed. All woody vegetation from the top of bank design elevation and lower was preserved. The upstream half of the preserved vegetation was pruned to a height of approximately three feet. After removal of vegetation, the treatment area was lowered to the design top of bank elevation from the preserved bank line extending 15 feet back or away from the bank line. This distance includes ten feet of bank treatment and an additional five feet of excavation for floodplain treatment. After the bank line was excavated to the design top of bank elevation, the area behind the bank was excavated starting at the point furthest from the bank and working towards the bank. Contaminated material was removed to the PDP excavation depth (base of tailings plus 0.5 feet) for this location (4,775.5 feet). The purpose of excavating from the furthest extent of removal towards the bank line was to determine the point at which living roots of the preserved woody vegetation were encountered. Material was removed to within two feet of the bank before living roots were encountered in the excavation wall. Excavation did not continue past this point (Figure 7).

The excavation was backfilled to ten feet beyond the bank line (the extent of the bank treatment) to approximately 0.3 feet above the design top of bank elevation with imported floodplain alluvium (Attachment 1). Over-filling the bank treatment area allows for settling of placed alluvium and addresses the potential for erosion of placed material during spring high flows. From ten to 15 feet beyond the bank line (floodplain treatment area), the excavation was filled to one foot below the design floodplain elevation. After excavation and fill of the floodplain treatment area to within one foot of the design floodplain elevation, a 3.5 foot deep trench was made using the excavator bucket at the interface of the bank treatment and the floodplain treatment, ten feet back from the bank line. Six to eight-foot long sandbar willow cuttings were inserted into this trench at a density of five per linear foot. Because the bank treatment and floodplain treatment were constructed simultaneously, the orientation of the willows is toward the channel rather than away from the channel as shown in the PDP Drawing D-2. Willow cuttings in the upstream half of the treatment were trimmed to approximately two feet above the ground.

Ten, eight-gallon container sandbar willows were planted in the floodplain treatment area. Five of the ten plants (plants 1, 3, 5, 7, and 9 counted from downstream to upstream) were treated with mycorrhizae supplements (Myco Apply®Soluble MAXX) and three packs of fertilizer (Leap Start, Forest Restoration Pro Booster Packs, 22-10-7 plus minors). After planting, the floodplain treatment area was brought up to design floodplain elevation with vegetative backfill material imported from the Beck property borrow site. All container willows were watered in to settle backfill material and ensure no air pockets were present in planting holes. Four of the ten plants (plants 1, 2, 5, and 6 counted from downstream to upstream) were fitted with browse protection consisting of rigid plastic mesh material to prevent cutting by beaver. Browse protectors were four feet tall and ranged from eight to 24 inches in diameter (Figure 6). Both the streambank treatment and floodplain treatment area surfaces were seeded with a mix containing shrub, forb, and grass species (Attachment 2). Seed was lightly raked to improve soil contact.

All material excavated during construction was hauled off site to the Opportunity Ponds Waste Management Area.

Figure 7. Modified Type 2 bank treatment excavation.

Figure 8 shows the Modified Type 2 bank treatment site before and after construction. Table 2 provides a list of materials used for the Type 2 bank treatment. The following key observations were made during construction of this treatment:

- Preserved woody vegetation is well rooted in the banks and rooted below excavation depth.
- The living roots observed in the excavation wall within two feet of the bank appear to be from plants that are also well rooted below the excavation depth.
- No bank sloughing or slumping of vegetation occurred during excavation. Leaving two feet of existing material intact appears to provide sufficient stability for preserved vegetation during excavation. Continued stability of vegetation should be monitored.
- The root crowns of preserved vegetation were at variable heights after excavation to the design top of bank elevation. Similar to the Type 2 bank treatment site, any vegetation greater than one foot above the top of bank design elevation was removed.

- No significant gaps in vegetation were present at this site after removal of vegetation above the design top of bank elevation. Because bank material is left in place, small gaps in vegetation (five feet or less) will not likely affect the stability of banks using the Modified Type 2 treatment.
- The native bank substrate consisted of clay loam.
- Based on observations of soil color alone (obvious soil contamination being bright orange or yellow in color), it appeared that excavation of material to the design top of bank elevation and within two feet of the bank resulted in removal of most contamination (soil profile seen at top of photo in Figure 7).
- Placing willow cuttings at the interface of the bank treatment and floodplain treatment may not be necessary, particularly in areas where planting units overlap with bank treatments.
- The water surface elevation in the channel at the time of bank construction was 4,777.8 feet.
- Backfill of the excavation area was completed one day after excavation. During this period, the excavation area filled with water to within one foot of the water surface in the channel. For this reason, it was not possible to compact the placed floodplain alluvium. This may not be a significant issue during construction of the grading plan when the dewatering plan is in place and the excavation is not confined to a small area.
- Alluvium used in the pilot project consisted of a high percentage of particles less than 0.5 inches (Attachment 1). This material is smaller than the gradation provided in the PDP and may not be ideal for backfill of bank treatments.
- There was beaver browse of cuttings installed at the interface of the streambank and floodplain treatments and browse of all eight-gallon willows not fitted with browse protectors one week after construction.
- No microtopography was constructed in the floodplain treatment portion of the treatment area. Microtopography is included in the PDP for this area.
- Water quality was not impacted during construction (see Attachment 3).

Based on these observations, it is recommended that wherever feasible the Type 2 bank treatment is changed to the Modified Type 2 bank treatment for final design. The Modified Type 2 bank treatment would have the following design elements:

- Excavation of existing vegetation to the top of bank design elevation.

- Excavation to the base of tailings plus 0.5 feet excavation depth. Excavation should leave two feet of existing material in place immediately behind the preserved vegetation.

Figure 8. Modified Type 2 bank treatment site prior to construction (photo left) and after construction (photo right).

Table 2. Modified Type 2 bank treatment quantities.

Material Type	**Quantity**
Excavated material	150 cubic yards
Imported alluvium placed	85 cubic yards
Vegetative backfill	18 cubic yards
6-8 foot willow cuttings	250
8-gallon sandbar willows	10

Effectiveness Monitoring

The effectiveness of the bank treatments implemented as part of the streambank pilot project should be observed during 2012 spring run-off and during the subsequent growing season to evaluate treatment function and ensure that observations made during construction are valid. The following observations should be made at each site:

- Movement of preserved vegetation (i.e. resulting in slumping of the bank, loss of bank material or bank erosion)
- Settling of backfill material
- Loss of backfill material during high flows
- New growth on pruned, preserved vegetation
- Stability of pruned versus un-pruned preserved vegetation
- Willow cutting survival, growth and browse (trimmed versus untrimmed)
- Survival of eight-gallon willows
- Browse of eight-gallon willows (including beaver browse and damage)
- Cover of seeded species (on alluvium versus vegetative backfill substrate)

Criteria for Changing Type 2 Treatment (Single Vegetated Soil Lift) to the Modified Type 2 Bank Treatment (Preserve Vegetation)

On Wednesday, April 4 2012, the design team reviewed banks throughout the Phase 1 project area designated as Type 2 bank treatments in the Preliminary Design Plan (PDP). During the review, the design team identified Type 2 bank treatment locations that should be modified in the final design based on the results of the streambank pilot project. This section describes the criteria developed to make that determination.

The following criteria were used to determine if the use of the Modified Type 2 bank treatment would be acceptable:

- Bank is continuously vegetated below the design top of bank elevation and woody stems are mostly alive.
- Both vegetation and cohesive bank material contribute to bank stability.
- Bank toe is intact (i.e. minimal undercutting of bank, bank material is cohesive or alluvium, minimal beaver holes or other disturbances).

If all of the criteria listed above were not met the bank either remained designated as a Type 2 treatment or in some instances, changed to a Type 3 bank treatment (double layer vegetated soil lift). If a bank meets criteria for a Modified Type 2 bank treatment, but is located at the downstream overflow return point of a meander core, the bank remained a Type 2 treatment. The criteria for maintaining a bank as Type 2 treatment includes all of the following:

- Bank is vegetated below the design top of bank elevation with live woody stems, but woody vegetation is not continuous or localized erosion is occurring between woody vegetation clumps.
- Bank material is cohesive.
- Bank toe is intact (i.e. minimal undercutting of bank, bank material is cohesive or alluvium, minimal beaver holes or other disturbances).

In a few instances, banks designated as Type 2 bank treatments were changed to Type 3 bank treatments (double layer vegetated soil lift) if one or more of the following criteria were met:

- Bank vegetation is mostly herbaceous species, sparse woody vegetation, or decadent woody vegetation.
- Bank material is not cohesive or is actively eroding.
- Bank toe is eroding or has high potential for erosion.

Figures 9 and 10 illustrate banks that initially were designated as Type 2 bank treatments in the PDP but meet the criteria listed above for the Modified Type 2 treatment. Figure 11 illustrates a Type 2 bank treatment site that was modified to a Type 3 bank treatment (double vegetated soil lift) during the April 4, 2012 design team field visit. Figure 12 illustrates a Type 3 bank treatment site. The changes to bank treatment designations will be incorporated into the final design for the Phase 1 project.

Figure 9. Bank designated in the PDP as Type 2 bank treatment (single vegetated soil lift) that was changed to a Modified Type 2 bank treatment (preserve vegetation) based on criteria determined by design team after implementation of the streambank pilot project.

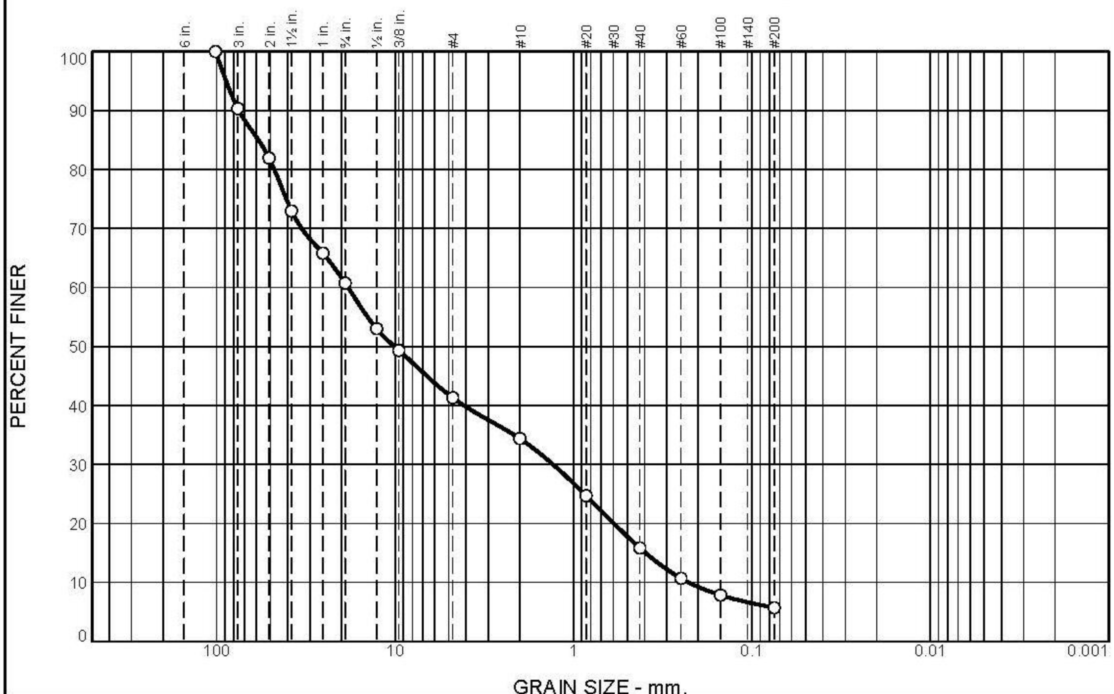
Figure 10. Bank designated in the PDP as Type 2 bank treatment (single vegetated soil lift) and changed to Modified Type 2 bank treatment (preserve vegetation) based on criteria determined by design team after implementation of the pilot project.

Figure 11. Type 2 bank treatment (single vegetated soil lift) site located on the right bank at station 88+00 that was changed to the Type 3 (double vegetated soil lift) bank treatment. Vegetation is mostly decadent, the bank consists of sandy material, and the toe is eroding.

Figure 12. Non-cohesive bank material and unstable toe at station 68+00. This location is designated as a Type 3 bank treatment (double vegetative soil lift).

Attachment 1. Imported Floodplain Alluvium gradation

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
9.7	29.6	19.4	6.9	18.6	10.1	5.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
4	100.0		
3	90.3		
2	81.9		
1.5	73.0		
1	65.8		
.75	60.7		
.5	53.0		
.375	49.3		
#4	41.3		
#10	34.4		
#20	24.7		
#40	15.8		
#60	10.7		
#100	7.8		
#200	5.7		

* (no specification provided)

Soil Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 75.2212 D_{85}= 58.3076 D_{60}= 18.3585
D_{50}= 10.0921 D_{30}= 1.3046 D_{15}= 0.3949
D_{10}= 0.2267 C_u= 81.00 C_c= 0.41

Classification

USCS= AASHTO=

Remarks

Location: Hollow Pit
Sample Number: 12288

Date: 3-6-12

PIONEER TECHNICAL SERVICES, INC.

Client: Intermountain Construction Services
Project: ICS Materials Testing
Project No: 13643
Figure

Attachment 2: Seed Mix

GRASSES
Prairie cordgrass
Basin wildrye
Western wheatgrass
Streambank wheatgrass
Slender wheatgrass
Tufted hairgrass
Alkali sacaton
American mannagrass
Alkaligrass
Canada wildrye
Nevada bluegrass
Canada bluegrass
American sloughgrass
Sherman big bluegrass

FORBS
Red clover
Bird's-foot trefoil
Mountain goldenbanner
Canada milkvetch
Annual sunflower
Rocky Mountain bee plant
Dutch white clover
Common yarrow

SUB-SHRUBS
Cudseed sagewort
Tarragon

SHRUBS
Silver sagebrush
Basin big sagebrush
Greasewood
Silver buffaloberry

Attachment 3. Water Quality Monitoring

M E M O R A N D U M

To: Amy Sacry, Geum & Karin Boyd, AGI
From: Brian Bartkowiak, MT DEQ
Date: April 23, 2012
Subject: Reach A, Phase 1 Streambank Pilot Project Surface Water Monitoring

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This memorandum summarizes the results of the surface water monitoring during the implementation of the Reach A, Phase 1 Streambank Pilot Project (Project) in Warm Springs, Montana. The Project was implemented from March 19, 2012 to March 21, 2012 and included the removal of tailings, construction of approximately one hundred feet of streambanks, replacement with clean borrow materials, and the revegetation of disturbed areas. Monitoring of water quality parameters during the Project was used to ensure that the construction methods would not adversely affecting surface water quality in the Clark Fork River (CFR). The results of the water quality monitoring were used to evaluate the effectiveness of this specific construction technique and to determine an active river water management system or if additional BMPs would be required to control sediment discharge. The complete monitoring procedures are contained in the Reach A, Phase 1 Streambank Pilot Project, prepared by Geum Environmental Consulting, Inc. and the Montana Department of Environmental Quality.

1 Field Activities

Monitoring during construction activities included water quality monitoring of turbidity and, as necessary, total suspended solids (TSS), hardness, and totals metals, including arsenic in the CFR. Turbidity measurements were taken regularly and an effort to take measurements during "worst case" conditions, i.e. when there were visible turbidity entering the river. The initial water quality of the CFR was evaluated by collecting water quality data before construction activities began.

The monitoring water quality parameters were collected at two locations along the CFR: a baseline location upstream of the construction activities (Upstream) and a downstream location below the estimated mixing zone from the project work limits (Downstream), as shown on Figure 1. The baseline, upstream sampling location was located in a riffle approximately 247 feet upstream of the construction limits on the southwest side of the CFR. The downstream location was located on a riffle approximately 409 feet downstream of the construction limits on the southwest side of the CFR. The downstream location was located just outside of the estimated mixing zone, where initial dilution of discharges took place and where water quality changes were expected to occur. The mixing zone was assumed to consist of the segment of the stream beginning at the discharge location and extending for a distance downstream of ten times the stream width, as indicated in the Montana DEQ Construction Dewatering General Permit (CDGP) under the Montana Pollutant Discharge Elimination System (MPDES) (DEQ, 2005).

Figure 13. Location of water quality monitoring points in relation to bank treatment areas.

Turbidity warning limits were pre-established for this Streambank Pilot Project. According to ARARs, the maximum allowable increase above naturally occurring turbidity is 10 nephelometric units (NTU) for a C-2 class stream (i.e., the classification of the CFR at the Project site). Using this information and the historical turbidity data presented, a turbidity level of 12 NTU is established as the “turbidity warning limit.” This warning limit is 80% of 15 NTU (the maximum allowable limit), calculated assuming an average baseline turbidity value of 5 NTU plus the 10 NTU allowable turbidity increase.

2 Results and Discussion

The Pilot Project began on March 19, 2012 and was completed on March 21, 2012. There was no active water management system used during the streambank pilot project and no BMPs in place. The methods of constructing streambanks adequately controlled both the surface water and sediment discharge.

2.1 Background Measurements

Background turbidity measurements were collected from March 12, 2012 through March 15, 2012 and are presented in Table 1. The measurements were collected before any construction activities began on the Project. Measurements were collected from both upstream and at the downstream locations.

Table 1. Background Turbidity Measurements.

Date	Upstream Turbidity (NTU)	Downstream Turbidity (NTU)
3/12/2012	1.1	1.3
3/13/2012	1.5	1.4
3/14/2012	1.6	1.6
3/15/2012	1.9	2.1
Average	**1.5**	**1.6**

Two water quality samples were collected, one on March 12, 2012 and one on March 13, 2012, from both the upstream and the downstream locations on the CFR. The samples were analyzed for total suspended solids, hardness, dissolved metals, and total metals. The results of the sampling are presented in Table 2 and Table 3. The results of the background sampling were consistent with the historical results of the water quality data collected at USGS Station #12323800 on the CFR at Galen.

Table 2. Background Total Suspended Solids and Hardness.

Date Collected	Location	Total Suspended Solids (mg/L)	Hardness as $CaCO_3$ (mg/L)
3/12/2012	Upstream	ND	187
3/12/2012	Downstream	ND	183
3/13/2012	Upstream	ND	182
3/13/2012	Downstream	ND	189

Table 3. Background Dissolved and Total Metals.

Date Collected	Location	Dissolved Metals					Total Metals				
		Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
3/12/2012	Upstream	0.008	ND	55	ND	ND	0.009	ND	0.007	0.001	ND
3/12/2012	Downstream	0.008	ND	53	ND	ND	0.009	ND	0.007	0.001	0.01
3/13/2012	Upstream	0.008	ND	53	ND	ND	0.009	ND	0.007	0.002	0.01
3/13/2012	Downstream	0.008	ND	56	ND	ND	0.009	ND	0.007	0.002	0.01

2.2 Construction Monitoring

Turbidity measurements were collected during construction activities from March 19, 2012 through March 21, 2012 and are presented in Table 2. The surface water measurements were collected during "worse case" conditions, i.e. where there was visible turbidity entering the river.

Table 4. Construction Turbidity Measurements.

Date	Time	Upstream Turbidity (NTU)	Warning Limit (80% Maximum Allowable) (NTU)	Maximum Allowable Turbidity (NTU)	Downstream Turbidity (NTU)
3/19/2012	14:30	3.3	10.6	13.3	3.8
3/20/2012	10:15	3.6	10.9	13.6	3.8
3/20/2012	13:45	7.5	14.0	17.5	7.5
3/21/2012	10:00	3.7	11.0	13.7	3.7
3/21/2012	13:30	3.4	10.7	13.4	4
Average		**4.3**			**4.6**

The average increase in turbidity at the downstream location during construction was 0.3 NTU compared to an average pre-construction increase of 0.1 NTU. The sediment impact of the streambank construction techniques was minimal during the Project. The construction technique without the use of active river water management system or BMPs successfully limited the sediment discharge during the pilot project and thus limited any adverse affects to the surface water quality in the CFR.

One water quality sample was collected on March 21, 2012 from both the upstream and the downstream locations on the CFR. The sampling was timed take the samples during "worst case" conditions, i.e. when there were visible turbidity entering the river. The samples were analyzed for total suspended solids, hardness, dissolved metals, and total metals. The results of the sampling are presented in Table 5 and Table 6. The samples were collected during construction to determine if there was an increases in total suspended solids and/or total and dissolved metals associated with the construction.

Table 5. Construction Total Suspended Solids and Hardness.

Date Collected	Location	Total Suspended Solids (mg/L)	Hardness as $CaCO_3$ (mg/L)
3/21/2012	Upstream	ND	189
3/21/2012	Downstream	10	189

Table 6. Construction Dissolved and Total Metals.

		Dissolved Metals					Total Metals				
Date Collected	Location	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
3/21/2012	Upstream	0.007	ND	ND	ND	ND	0.01	ND	0.014	0.004	0.02
3/21/2012	Downstream	0.007	ND	ND	ND	ND	0.01	ND	0.014	0.004	0.02

Sample results showed that there was no increase in total or dissolved metals during construction. Total suspended solids at the upstream station was ND (non-detect) and was at the reporting limit of 10 mg/L at the downstream station. This result is most likely due to variability in the analysis and does not represent a practicable increase in total suspended solids.

3 References

DEQ. 2008. *Circular DEQ-7 Montana Numeric Water Quality Standards*. Montana Department of Environmental Quality Planning, Prevention, and Assistance Division – Water Quality Standards Section. February 2008.

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